

REMOVAL OF SiON RESIDUE AFTER CMP

FIELD OF THE INVENTION

The invention relates to the general field of chem. mech. polishing with particular reference to polishing surfaces of silicon oxynitride and the removal of all associated particle residue.

BACKGROUND OF THE INVENTION

Referring to FIG. 1, we note that, for certain technology families notably 0.18 micron logic, it is necessary to use a layer of silicon oxynitride 13 (in conjunction with a titanium nitride layer 14) to serve as a bottom anti-reflection coating (BARC) prior to coating with photoresist. This facilitates patterning of via holes, such as 16, that will be etched through an inter-metal dielectric layer 12. The latter sits on substrate 11 which is typically a layer of wiring. This would then be followed by over-filling the via holes with tungsten layer 15. The latter is then planarized by means of CMP (chemical mechanical polishing). Planarization is performed in two steps. First, most of the tungsten is removed, as shown in FIG. 2. The wafer is then moved to a different platen where titanium nitride layer 14 and the remaining tungsten are removed, as shown in FIG. 3.

It has, however, been found that tungsten CMP doesn't completely remove all silicon oxynitride from the surface and that a residue of silicon oxynitride particles get left behind. These are shown in FIG. 4 as particles 41 on the surface of dielectric layer 12. Several processes have been tried to cause the removal of the silicon oxynitride particles. For example, an extra step of de-ionized water (DIW)-buffing can usually achieve the removal of the particles but this is time consuming and requires another dedicated tool for the task. A process that can be added in situ to the existing process, rather than being part of a post CMP cleaning step, is also to be preferred.

A routine search of the prior art was performed with the following references of interest being found:

US 5,704,987 (Huynh et al.) show a post CMP clean using TMAH (tetramethyl ammonium hydroxide). Naghshineh et al. in US 6,194,366 B1 show a post CMP clean comprising TMAH. In US 6,152,148, George et al. also show a post CMP clean that uses TMAH, as do Wang et al. in US 6,099,662. US 5,981,454 (Small), US 6,044,851 (Grieger), US 6,235,145 B1 (Li et al.), US 6,046,112 (Wang), US 6,114,241 (Choi et al.), and US 5,679,169 (Gonzales et al.) describe Post CMP clean comprising TMAH.

SUMMARY OF THE INVENTION

It has been an object of at least one embodiment of the present invention to provide a process for CMP of a silicon oxynitride surface.

Another object of at least one embodiment of the present invention has been that said process should not lead to leaving a residue of silicon oxynitride particles on the surface from which the layer of silicon oxynitride was removed.

Still another object of at least one embodiment of the present invention has been that said process be readily incorporated as part of the standard process used for the formation of tungsten studs in silicon integrated circuits, particularly for the 0.18 micron logic family of circuits.

A further object of at least one embodiment of the present invention has been that said process not require additional specialized apparatus for its implementation.

These objects have been achieved by subjecting the surface from which the silicon oxynitride was removed to a high pressure rinse in an aqueous solution that includes a surfactant such as tetramethyl ammonium hydroxide or isopropyl alcohol. These surfactants serve to modify the hydrophobic behavior of the silicon oxynitride particles so

that they no longer cling to the surface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a dielectric layer through which a via hole has been etched, over-filled with tungsten prior to CMP.

FIG. 2 shows FIG. 1 after the tungsten layer has been planarized.

FIG. 3 shows FIG. 2 after the remaining tungsten and the titanium nitride are removed from the surface of the silicon oxynitride.

FIG. 4 is a schematic illustration showing how particles of silicon oxynitride remain clinging to the surface after removal of the silicon oxynitride.

FIG. 5 illustrates a key feature of the invention, namely cleaning the surface with a high pressure spray that includes a suitable surfactant.

FIG. 6 illustrates surface appearance after the process illustrated in FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As discussed above, the process of the present invention begins as shown in FIG. 1 where a layer of tungsten between about 0.3 and 0.5 microns thick is used to overfill the via. After a first CMP step, on a first platen, the tungsten thickness is reduced to between about 0.1 and 0.2 microns. This is followed by a second CMP step on a second platen during which the remaining tungsten and the immediately underlying titanium nitride layer are both removed. Then, in a third CMP step on a third platen, the layer of silicon oxynitride needs to be removed. As already noted, this step, using prior art methods, results in silicon oxynitride debris being left behind on the surface.

We have determined that the reason that silicon oxynitride particles tend to remain on the surface after the oxynitride has been removed by CMP is that silicon oxynitride is slightly hydrophobic. So a simple water rinse immediately after CMP is insufficient to pry the oxynitride debris off the wafer surface. We have therefore introduced the use of a surfactant into the process immediately after the CMP of the silicon oxynitride has been completed. This modifies the hydrophobic behavior of the oxynitride making its removal from the wafer surface easier.

Two surfactants, TMAH and isopropyl alcohol (IPA), were evaluated although similar behavior would be expected from other, similar, materials. TMAH was diluted in

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DIW to make a solution of 2.5-5 weight % , while IPA was added to DIW to make a solution of 10-50 weight %. TMAH is supplied by CCP chemistry Co Ltd. These surfactants were not added to the slurry that was used with CMP because of their known effects on slurry characteristics. Instead, they were applied to the surface in the form of an in situ high pressure rinse. However, the flow rate of the rinsing fluid, which is controlled by a Mirra rotating pump, was increased from 100ml/min. to 300 ml/min. This step is schematically illustrated in FIG. 5 which shows dispenser 52 squirting a jet of fluid 51 (as disclosed above) onto the surface of dielectric layer 12 after the latter has been exposed due to the removal by CMP of layers 14 and 15 (see FIG. 2). Several residual oxynitride particles 41 are also shown on the surface, said particles having not yet been exposed to jet 51. The high pressure rinse was applied for between about 5 and 20 seconds, which is substantially less time than would have been needed if DIW had been used alone.

As illustrated in FIG. 6, by using the disclosed surfactants in the concentrations stated and in the manner described, the oxynitride particles could be removed from the dielectric surface at this stage of the process. The surfactants were effective because of their effect on the surface charge, that is the isoelectric point (IEP) of oxynitride is close to 6-7, whereas that of silicon oxide, for example, is about 3. The IEP is the pH at which the net charge on a particle is zero. Accordingly, the pH was set to 9 when TMAH was used and to 8 when IPA was used. Thus, for any effective surfactant, a pH between about

1875 1876 1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2

What is claimed is: